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CONTENTS

Revised standard-frequency broadcasts.
Absolute determination of the ampere.
Intercomparison of platinum resistance thermometers.
Spectrographic analysis of commercial tin.
Calculation of protein-anion affinity constants from acid-titration data.
Affinities of anions of strong acids for wool protein.
Specification for folding chairs for school use.
Stresses in knees of rigid frames.
Redesign and substitution in building construction.
Preparing the local building code.
Simplified practice recommendation for forged axes.
Simplified practice recommendation for fiber boxes for canned fruits and vegetables.
Screw-thread standards for Federal services.
Sixteen-place table of natural logarithms.
New and revised publications issued during January 1942.
Mimeographed material: Letter Circulars.
Recent Bureau articles appearing in outside publications.

REVISED STANDARD-FREQUENCY BROADCASTS

The standard-frequency service of the Bureau's station, WWV, has been extended to include another carrier frequency (15 Mc). The broadcast is continuous from 1-kw transmitters, and carries the standard musical pitch and other features. The radio frequencies are 5 Mc (5,000 kc, 5,000,000 c/s), 15 Mc (15,000 kc, 15,000,000 c/s).

The standard musical pitch is the frequency 440 cycles per second, corresponding to A above middle C. In addition, a pulse every second is heard as a faint tick when listening to the 440 cycles. The pulse lasts 0.005 second, and provides an accurate time interval for purposes of physical measurements.

The 440-cycle tone is interrupted every 5 minutes for 1 minute in order to give the station announcement and to provide an interval for checking radio measurements based on the standard radio frequency. The announcement is the station call letters WWV in telegraphic code (dots and dashes).

The accuracy of the 5- and 15-Mc frequencies, and of the 440-cycle standard pitch as transmitted, is better than 1 part in 10,000,000. Transmission effects in the medium (Doppler effect, etc.) may result in slight fluctuations in the 440-cycle frequency as received at a particular place; the average frequency received is, however, as accurate as that transmitted. The time interval marked by the pulse every second is accurate to 0.00001 second. The 1-minute, 4-minute, and 5-minute intervals, synchronized with the seconds pulses and marked by the beginning and ending of the announcement periods, are accurate to 1 part in 10,000,000. The beginnings of the announcement periods are so synchronized with the basic time service of the United States Naval Observatory that they mark accurately the hour and the successive 5-minute periods; this adjustment does not have the extreme accuracy of the time intervals, but is within a small fraction of a second.

In general, during the winter day, the 5-Mc carrier frequency can be used at all distances out to about 1,000 miles and the 440-cycle tone out to about 700 miles; the 15-Mc carrier frequency is usable from about 800 to 5,500 miles, and the 440-cycle tone from about 800 to 4,000 miles. During the winter night,

[1] Published with approval of the Director of the Budget.

i. e., between about 8 p. m. and 6 a. m. EST, the 5-Mc carrier frequency is usable from about 700 to 7,000 miles and the 440-cycle tone from about 700 to 5,000 miles; the 15-Mc broadcast is not usable during the winter night, except for the short-distance ground wave (see below). During the summer day, the 5-Mc carrier frequency is usable at all distances out to about 400 miles and the 440-cycle tone out to about 300 miles; the 15-Mc carrier frequency is usable from about 900 to 3,000 miles and the 440-cycle tone from about 900 to 2,500 miles. During the summer night before midnight EST, the 5-Mc carrier frequency is usable out to about 2,500 miles and the 440-cycle tone out to about 1,400 miles, except for a period of 2 or 3 hours before sunrise, when it is difficult to receive at distances between about 50 and 400 miles; the 15-Mc carrier frequency is usable from about 1,000 to 7,000 miles and the 440-cycle tone from about 1,000 to 5,000 miles.

Besides the distances covered by the sky wave as just described, the ground wave provides coverage at short distances as follows. At all times, the 5-Mc carrier frequency is usable out to about 100 miles and the 440-cycle tone out to about 50 miles; and the 15-Mc carrier frequency is usable out to about 70 miles and the 440-cycle tone out to about 35 miles.

The service will be continuous except for such break-downs as may possibly occur because of the use of temporary apparatus. Work is progressing as rapidly as possible on a new station to provide more fully than in the past standard frequencies reliably receivable at all times throughout the country and adjacent areas.

ABSOLUTE DETERMINATION OF THE AMPERE

In many types of measurements both electrical and mechanical units are involved. For instance, in a turbogenerator it is often necessary to measure the power input in terms of mechanical and thermal units and the power output in electrical units. In studying the efficiency of such a system, it is important to be able to express all the measured quantities in terms of the units of one system. Fortunately, this principle was early realized, so that our electrical units are all based on the mechanical units of mass, length, and time. Values of electrical standards were established in terms of these mechanical units nearly three-quarters of a century ago. However, with improved methods of measurement a demand has arisen for a redetermination of the values of our electrical standards in terms of the mechanical units, giving them more accurate values than were possible by means of the earlier measurements. The result obtained when an extremely precise determination is made of an electrical quantity in terms of the mechanical units is called its absolute value.

For over 10 years, the Bureau has been engaged on determinations of the values of its electrical standards in terms of the absolute values of the units. In the Journal of Research for February (RP1449), Roger W. Curtis, Raymond L. Driscoll, and Charles L. Critchfield describe their work on the standardization of the ampere. This was accomplished with an instrument known as a current balance, in which the force of attraction between coils carrying electric currents is measured (Technical News Bulletin 265 (May 1939)). The coils were made with extreme care, and their dimensions were determined with high precision. The force is measured by comparing it with the gravitational force on a known mass by means of the sensitive balance. Using the measured dimensions and the force, the value of the current in absolute units can be computed. This same current is measured in the international units, and thus a comparison between the two systems of units can be made. From such measurements it has been established that the absolute unit of current is larger by 150 parts in a million than the international unit.

INTERCOMPARISON OF PLATINUM RESISTANCE THERMOMETERS

The fundamental scale of thermometry today for both scientific and industrial uses is the scale based on the two laws of thermodynamics which Lord Kelvin proposed in 1854. The establishment of this thermodynamic scale for accurate calibrations of practical thermometers requires very elaborate gas thermometers which are not generally available. Further, the precision attained with gas thermometers has not been as high as that more easily obtainable with other instruments and apparatus.

In 1927, in Paris, the International Committee on Weights and Measures, composed of representatives of the principal nations, proposed the International Temperature Scale as a more convenient and more precise method of calibrating thermometers than by comparison with

gas thermometers. This scale reproduced the thermodynamic scale as accurately as the latter could then be established. This International Temperature Scale has been adopted by the principal standardizing laboratories of the world for scientific and industrial purposes. From —190° to +660° C it is based upon the electrical resistance of a "strain-free" coil of "pure" platinum wire. The relation between the resistance, R, of platinum wire and temperature, t, on the International scale is expressed by the equations:

from 0° to 660° C,

$$t=\frac{R-R_0}{R_{100}-R_0}100+\delta\left(\frac{t}{100}-1\right)\frac{t}{100} \quad (1)$$

from —190° to 0°,

$$t=\frac{R-R_0}{R_{100}-R_0}100+\delta\left(\frac{t}{100}-1\right)\frac{t}{100}+\beta\left(\frac{t}{100}-1\right)\frac{t^3}{100}, \quad (2)$$

where R_0 and R_{100} are the resistances of the thermometer at the standard freezing and boiling points, respectively, of water, and δ and β are constants, the values of which are determined by calibrating the thermometer at the standard freezing point of water and the standard boiling points of water, sulfur, and oxygen. The numbers assigned to the temperatures of these calibration points in the definition of the scale are 0°, 100°, 444.6°, and —182.97° C.

It is impossible to obtain absolutely pure platinum wire and to mount any wire in an absolutely strain-free manner. The introduction of other substances as impurities in platinum and residual strains influence the relation which exists between temperature and the resistance of the wire. Samples of platinum wire differing in purity and mechanical condition will give rise, therefore, to different scales of temperature, just as different metals like nickel and platinum would be expected to do. This was realized when the International Temperature Scale was defined, and limits were placed upon the platinum coils, which at the time were thought to be reasonable and yet stringent enough to insure good reproducibility of the scale. Until now, however, no investigation has been made to determine the differences between the scales of different thermometers that arise from the small variations in the platinum permitted by the scale.

Differences between the scales of different thermometers may arise in still another way, namely, from errors made in the calibration of thermometers at the ice, steam, sulfur, and oxygen points, either in the measurement of the resistances of the thermometers or in the establishment of standard conditions at the calibration points. Actually, these are not errors in the ordinary sense of the word, because they arise from the practical limits of precision of calibration and not as a result of carelessness or oversight. Nevertheless, they should be taken into account in a determination of the effect of variations in impurities and strains in wire of different thermometers. This has been done in an investigation by Harold J. Hoge and Ferdinand G. Brickwedde, which is fully described in RP1454 in the Journal of Research for February.

Eight platinum resistance thermometers calibrated in accordance with the International Temperature Scale, all satisfying the requirements for purity and strain-free condition of the platinum, were compared at temperatures from —190° to +445°C by measuring with each thermometer the temperature of a thermostated block of metal.

After minimizing the relative calibration errors, the maximum differences between readings of the seven best thermometers whose δ's in equations 1 and 2 ranged from 1.4936 to 1.4986 were 0.007 degree between —190° and 0° C, and 0.001_3 degree between 0° and 100° C. Maximum differences from the mean were 0.004 and 0.000_8 degree, respectively. For the eighth thermometer, whose δ was 1.5116, deviations from the mean of the seven others were 0.015 at —110° C and 0.003 at +50° C.

The results of this investigation may be used to determine more stringent limitations for the platinum of resistance thermometers in order to improve the reproducibility of the International Temperature Scale at low temperatures.

SPECTROGRAPHIC ANALYSIS OF COMMERCIAL TIN

The Bureau analyzes samples of pig tin, tin pipe, tin-lined fittings, and fusible plugs for deleterious impurities under governmental specifications. Certain impurities seriously impair the effectiveness of tin products in use. For example, zinc or iron in amounts less than 1 percent, or other elements in larger quantities, may raise the melting point of a fusible plug above the safety limit. Such a plug, designed for protection of boilers, may fail, with resultant danger to life and property. Tin, one of the strategic elements, is not plentiful, and much reclaimed metal is finding its way back into use, adding to the importance of having rapid and reliable ana-

lytical methods. The wet-chemical analysis of tin is difficult and time-consuming when small amounts of impurities are involved. Bourdon F. Scribner, of the Bureau's Spectroscopy Section, therefore, investigated the practicability of substituting a spectrographic method of analysis. A satisfactory method was developed, the procedure, which is described in detail in the February Journal of Research (RP1451), being as follows:

The tin is fabricated into electrode rods for spark excitation by (1) melting and chill-casting where mixing of the sample is required or (2) compressing millings, or turnings, of the sample under high pressure. The light from the spark between the tin electrodes illuminates a spectograph which provides a photographic record of the spectrum. The intensities of selected impurity lines are measured relative to control lines of the tin spectrum by means of a photocell and galvanometer, incorporated in a microphotometer. The change of impurity-line intensity with concentration is measured for a series of samples of known composition and a curve is drawn relating these quantities. The analysis of an unknown sample is made by measuring line intensities in the same manner and then reading the concentration from the analytical curve. The method permits determination of 10 impurities: Antimony, arsenic, bismuth, cadmium, copper, indium, iron, lead, silver, and zinc. The error is usually of the order of ± 5 percent of the amount present, and may be decreased to ± 2 percent by close control of conditions.

The time required for the necessary determinations on six samples is 2 hours, as compared with 2 days for the equivalent routine wet-chemical analysis. Other advantages of the spectrographic method lie in the use of small samples and the certainty of detection of uncommon impurities. The spectographic method has replaced the routine wet-chemical method at the Bureau for the analysis of tin of commercial grades.

CALCULATION OF PROTEIN-ANION AFFINITY CONSTANTS FROM ACID-TITRATION DATA

In a paper in the Journal of Research for February (RP1452), Jacinto Steinhardt presents a modification of an earlier published method of calculating the affinities of acids for wool. These calculations are intended to serve as a basis for further work on the factors influencing the dyeing of this fiber. It is shown that the modified equations make possible a more complete description of the data on the combination of acids by wool than was permitted by these equations in their earlier forms.

AFFINITIES OF ANIONS OF STRONG ACIDS FOR WOOL PROTEIN

RP1453 in the February Journal of Research is a report by Jacinto Steinhardt, Charles H. Fugitt, and Milton Harris, covering a continuation of earlier studies by Research Associates of the Textile Foundation, of the factors influencing the dyeing of wool. Measurements of the affinities for wool of 18 additional strong acids have now been made. On the basis of newly introduced refinements in the method of calculating affinities, both the present and earlier results are computed and the affinity constants for a total of 33 different acids, several at more than one temperature, are tabulated. The assembled data indicate that a fairly consistent relation exists between the molecular weights of strong organic acids and their affinities for the fiber. Thus at one end of the series are the compounds of low molecular weight which have low affinities and can be readily washed from the wool. At the other end are the acids of high molecular weight, such as the acid dyes, which are bound so tightly that they are relatively fast to washing.

SPECIFICATION FOR FOLDING CHAIRS FOR SCHOOL USE

The need for a factual investigation to determine minimum requirements for school furniture and equipment has been recognized for many years. A specification for folding chairs is the first result of a study organized by the American Council on Education and established as a research associateship at the Bureau. Ninety-two chairs, submitted by eighteen manufacturers, were tested.

The specification is written in terms of use factors, leaving maximum freedom to the manufacturer in the methods adopted for meeting these use requirements. The specification sets certain minimum standards, and, in general, contains no description of sizes or shapes of structural parts or other details of construction. Exceptions are made when the shape or design of the part directly affects the use of the chair, or where, in some instances, manufacturing procedure is standardized and performance tests completely covering the construction would be highly complicated and expensive. The chairs submitted were

measured for compliance with principles of safety, comfort, and posture, and tested for strength and durability. Before the requirements were included in the specification, the results of these measurements and tests were compared with experience in schools.

The method of approach adopted in this instance is essentially practical and direct, and the specification can be used immediately by school administrators. It is hoped that this initial step will lead to the wide application of the principle of buying through specifications written in terms of school needs.

STRESSES IN KNEES OF RIGID FRAMES

Steel rigid frames, a type of construction in which horizontal and vertical members are rigidly connected to each other at their ends, have become more and more common in recent years. Rational design of such frames involves the analysis of the stresses in the knee, that is, the part of the structure connecting the horizontal and vertical members. Knees of rigid frames are of different shapes. When the top and bottom surfaces of the horizontal member are parallel, and the inside and outside surfaces of the vertical member are parallel, the knee may be rectangular in shape. In the simplest possible case the knee is merely a rectangular plate loaded along two adjacent edges by the forces exerted on it by the horizontal member and the vertical member. These forces may be resolved into normal forces (producing tension or compression), shearing forces (tending to produce sliding) and couples (tending to produce rotation). In a paper by William R. Osgood (RP1450) in the Journal of Research for February, the effect of the couples is considered, and expressions are found that give the stress due to them at any point of the knee.

REDESIGN AND SUBSTITUTION IN BUILDING CONSTRUCTION

In building structures during the present emergency, engineers and contractors must resort to many expedients because of the shortage of materials to which they are accustomed.

In an article in the Engineering News Record for January 15, 1942, H. L. Whittemore gives carefully selected suggestions directing attention to materials and methods which are not widely used by the construction industry.

He points out that the amount of steel required for steel structures and for the reinforcement of concrete structures can be decreased considerably by making use of up-to-date methods of design.

During recent years, large buildings have been erected, using wood frames—not the usual steel frames. These buildings clearly demonstrate that the once familiar wooden mill construction is entirely practicable for shops and other engineering structures.

It is, of course, essential that even emergency buildings be reasonably fire-resistant, but this can be accomplished without greatly increasing the cost by subdividing the structure with fire partitions.

PREPARING THE LOCAL BUILDING CODE

Building codes are frequently criticized on the ground that they cause unnecessary expense of construction and discourage the use of new materials. Analysis of the reasons why codes become subject to this criticism and constructive suggestions for overcoming it are, however, rarely presented. In an article by George N. Thompson in the February issue of American City, the sources of some of the difficulties are given and constructive suggestions are offered so that a repetition of past errors may be avoided. The article is intended to be helpful to local code committees charged with the responsibility of drawing up new requirements or revising old ones.

Among the points mentioned in the article are problems connected with referring to standards of professional and technical organizations, ways of dealing with new materials, and extent of discretion that may be exercised by the building official.

It is also emphasized that legal problems may vary from one community to another and that it is important to ascertain limitations on methods of presentation and code enforcement, since these limitations may determine the approach to technical requirements in the code.

SIMPLIFIED PRACTICE RECOMMENDATION FOR FORGED AXES

Simplified Practice Recommendation R158–41, Forged Axes (the second revision of this recommendation), covering stock types and sizes of single-bit,

double-bit, and miscellaneous axes, became effective on December 1, 1941.

As first developed by the ax manufacturers and promulgated in 1935, the recommendation established a simplified schedule consisting of about 60 percent of the 845 varieties then being produced. In 1937 the industry approved certain changes proposed by the standing committee which reduced the stock list to 384 varieties, or 45 percent of the original number. The current revision further reduces the number of stock types and sizes to 199, or to only about one-fourth of the number of varieties stocked in 1935.

In addition to the simplified schedule, a brief history of the project and lists of members of the standing committee and of acceptors are included. Until printed copies are available, free mimeographed copies of R158–41 can be obtained from the Division of Simplified Practice, National Bureau of Standards, Washington, D. C.

SIMPLIFIED PRACTICE RECOMMENDATION FOR FIBER BOXES FOR CANNED FRUITS AND VEGETABLES

Simplified Practice Recommendation R146–41, the second revision of this recommendation, "Corrugated and Solid Fiber Boxes for Canned Fruits and Vegetables," became effective on December 1, 1941.

The original program, promulgated in 1933, established a simplified schedule of stock sizes of fiberboard shipping boxes, based on the 27 stock sizes of fruit and vegetable cans adopted earlier by the canners. In 1938 the recommendation was revised to provide a simplified list of box sizes for the 21 sizes of cans then recognized as standard.

The current revision is based on the arrangement of cans in boxes for the 41 standard-stock sizes of fruits and vegetable cans. In addition to the simplified schedule listing inside dimensions of the boxes for each size of can, number of cans per box, and arrangement of cans, this publication includes suggestions on sealing and loading boxes for shipment, and a brief history of the project. Pending the receipt of the pamphlets from the printer, mimeographed copies will be supplied without charge. Requests should be addressed to the Division of Simplified Practice, National Bureau of Standards, Washington, D. C.

SCREW-THREAD STANDARDS FOR FEDERAL SERVICES

Widely separated manufacturing plants producing interchangeable parts which must fit into equipment assembled in the Government's war-production program will be interested to learn of the publication of a revised edition of the Handbook on Screw-Thread Standards for Federal Services. The new edition is known as Handbook H28, and copies are obtainable from the Superintendent of Documents, Government Printing Office, Washington, D. C., at 35 cents each.

This publication, brought out by the Interdepartmental Screw-Thread Committee representing the War, Navy and Commerce Departments, supersedes Handbook H25 and includes various extensions, revisions, and additions. Its purpose is to present complete dimensional data upon which specifications may be based for a wide variety of threaded products needed to meet Government requirements.

Carrying the formal approval of the Secretaries of War, Navy, and Commerce, the standards set forth in the publication are mandatory, except where need for deviation is shown in specific instances. For the most part, the Federal standards conform to generally accepted commercial standards, with some exceptions made necessary by particular needs of the Federal services.

SIXTEEN-PLACE TABLE OF NATURAL LOGARITHMS

A new volume in the series of mathematical tables prepared by the Work Projects Administration for the city of New York under the sponsorship of the National Bureau of Standards, is now available. This, the tenth volume to be made available through the Bureau, contains 16 decimal-place values of the logarithms of the decimal numbers from 0.0000 to 5.0000, at intervals of 0.0001. Two previous volumes of logarithms, all to 16 places, have dealt with the integers from 1 to 50,000 and from 50,000 to 100,000.

These tables are convenient for engineers and computers who have frequent use for natural logarithms and wish to obtain them with the least possible effort and time. For such workers the demand seems to be for a table in which the number of significant figures given in the argument is sufficient to avoid all but simple mental interpolation.

The price of the new table is $2.00, which includes postage to addresses in the United States and in countries extending the franking privilege. Orders, with remittance, should be sent to the National Bureau of Standards, Washington, D. C. The identifying symbol of this particular volume is MT10. Be sure to include this in your order.

NEW AND REVISED PUBLICATIONS ISSUED DURING JANUARY 1942

Research Papers [2]

[Reprints from November and December 1941 Journal of Research]

RP1429. Sugar acetates, acetylglycosyl halides, and orthoacetates in relation to the Walden inversion. Harriet L. Frush and Horace S. Isbell. Price 10 cents.

RP1431. Stresses in a rectangular knee of a rigid frame. William R. Osgood. Price 5 cents.

RP1432. Estimation of aldehyde groups in hydrocellulose from cotton. Albert R. Martin, Leonard Smith, Roy L. Whistler, and Milton Harris. Price 5 cents.

RP1434. The planoflex, a simple device for evaluating the pliability of fabrics. Edwin C. Dreby. Price 10 cents.

RP1435. Relation of electromotive force to the concentration of deuterium oxide in saturated standard cells. Langhorne H. Brickwedde and George W. Vinal. Price 5 cents.

RP1437. Structure of tricalcium aluminate. Howard F. McMurdie. Price 5 cents.

RP1438. The carbohydrate content of collagen. John Beek, Jr. Price 5 cents.

RP1439. Heats of isomerization of the nine heptanes. Edward J. R. Prosen and Frederick D. Rossini. Price 5 cents.

RP1440. Free energies and equilibria of isomerization of the butanes, pentanes, hexanes, and heptanes. Frederick D. Rossini, Edward J. R. Prosen, and Kenneth S. Pitzer. Price 5 cents.

RP1441. Fluidity of triton F and xanthate solutions as a measure of cellulose degradation. Ralph T. Mease and Leland F. Gleysteen. Price 5 cents.

RP1443. A resistor furnace, with some preliminary results up to 2,000° C. R. F. Geller. Price 5 cents.

Handbooks [2]

H28. Screw-thread standards for Federal Services, 1942. (Supersedes H25 and the Reports of the National Screw Thread Commission). Price 35 cents.

Technical News Bulletin [2]

Technical News Bulletin 297, January 1942. Price 5 cents. Annual subscription 50 cents.

MIMEOGRAPHED MATERIAL

Letter Circulars

[Letter Circulars are prepared to answer specific inquiries addressed to the National Bureau of Standards and are sent only on request to persons having definite need for the information. The Bureau cannot undertake to supply lists or complete sets of Letter Circulars or send copies automatically as issued.]

LC671. Sources of information on paint and related materials. (Supersedes LC542.)

LC672. Electrical measuring instruments, meters, and their accessories: Publications by the staff of the National Bureau of Standards. (Supersedes LC554).

RECENT BUREAU ARTICLES APPEARING IN OUTSIDE PUBLICATIONS [3]

Platform overhang of vehicle scales. C. L. Richard. Scale J. (1703 East 84th St., Chicago, Ill.) 28, 5 (December 1941).

A multipurpose photoelectric reflectometer. Richard S. Hunter. Paper Trade J. (10 East 39th St., New York, N. Y.) 113, TS275 (November 27, 1941).

A central organization for fundamental research on rubber. Archibald T. McPherson. India Rubber World (420 Lexington Ave., New York, N. Y.) 105, No. 3, 255 (December 1, 1941).

Plastics in defense: National Bureau of Standards. Gordon M. Kline. Plastics Catalog 1942. (Breskin Publishing Corp., 122 East 42d St., New York, N. Y.) 29 (December 1941).

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[2] Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to Technical News Bulletin, 50 cents per year; Journal of Research, $3.50 per year (to addresses in the United States and its possessions and to countries extending the franking privilege; other countries 70 cents and $4.50, respectively.

[3] These publications are not obtainable from the Government. Requests should be sent direct to the publishers.

The technical cohesive strength of metals. D. J. McAdam, Jr. J. Applied Mechanics (Am. Soc. Mech. Engrs., 29 West 39th St., New York, N. Y.) 8, No. 4, A155 to 165 (December 1941).

Comparison of dynamical with other measurements of mortar bars exposed to sulfate solutions. F. B. Hornibrook. ASTM Bul. (Am. Soc. Testing Materials, 260 So. Broad St., Philadelphia, Pa.) No. 113, p. 25 (December 1941).

Statistical theory of the effect of dimensions and of method of loading upon the modulus of rupture of beams. John Tucker, Jr. Proc. Am. Soc. Test. Materials 41, 1 (1941).

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